# Ohio Agricultural Experiment Station.

# BULLETIN 124

WOOSTER, OHIO, MARCH, 1901.

## THE MAINTENANCE OF FERTILITY.

### FIELD EXPERIMENTS WITH FERTILIZERS ON CORN, OATS AND WHEAT IN 1899 AND 1900.

The Bulletins of this Station are sent free to all residents of the State who request them. All correspondence should be addressed to EXPERIMENT STATION, WOOSTER, OHIO.

NORWALK OHIO:
THE LANING PRINTING COMPANY,
1901

Ex. Sta. Bul. 124.

ORGANIZATION OF THE

# OHIO AGRICULTURAL EXPERIMENT STATION.

---

## BOARD OF CONTROL.

R. H. WARDER.....North Bend
J. T. ROBINSON.....Rockaway
HON. L. M. STRONG.....Kenton
THE GOVERNOR OF THE STATE, THE DIRECTOR OF THE STATION.....*Ex officio*

## OFFICERS OF THE BOARD.

J. T. ROBINSON.....President
R. H. WARDER.....Secretary
PERCY A. HINMAN.....Treasurer

## STATION STAFF.

| | | |
|---|---|---|
| CHARLES E. THORNE | Wooster | Director |
| WILLIAM J. GREEN | " | Horticulturist and Vice-Director |
| J. FREMONT HICKMAN, M. A. S. | " | Agriculturist |
| FRANCIS M. WEBSTER, M. S. | " | Entomologist |
| AUGUSTINE D. SELBY, B. Sc. | " | Botanist and Chemist |
| PERCY A. HINMAN | " | Bursar |
| JOHN W. AMES, B. Sc. | " | Assistant Chemist |
| JOHN F. HICKS | " | Assistant Botanist |
| WILMON NEWELL, M. Sc. | " | Assistant Entomologist |
| J. C. BURNESON, V. S. | " | Veterinarian |
| CLARENCE W. WAID, B. Sc. | " | Assistant Horticulturist |
| WILLIAM HOLMES | " | Foreman of Farm |
| CHARLES A. PATTON | " | Ass't Foreman and Meteorologist |
| ANNIE B. AYRES | " | Mailing Clerk |
| CARY WELTY | " | Mechanic |
| EDWARD MOHN | Strongsville | Supt. Northeastern Sub-Station |
| LEWIS SCHULTZ | Neapolis | Supt. Northwestern Sub-Station |

---

**The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.**

# BULLETIN

OF THE

# Ohio Agricultural Experiment Station.

NUMBER 124. MARCH, 1901.


## THE MAINTENANCE OF FERTILITY.

### FIELD EXPERIMENTS WITH FERTILIZERS ON CORN, OATS AND WHEAT, 1899 AND 1900.*

The general plan of these experiments is given in Bulletin 110, which contains the statistics of the corn crops grown up to and including the year 1898, and other crops for one year later.

#### THE FIVE-YEAR ROTATION.

Table I shows the plan of distribution of fertilizers in this experiment. In the spring of 1899 a few changes were made in this plan, in the hope of securing a more effective comparison of carriers of nitrogen, as experience had shown that the quantity of nitrogen hitherto applied had been relatively large, for the soils under test, and consequently the crops had found more than enough available nitrogen to supply their needs in all the different carriers. The evident hunger of these soils for phosphoric acid and their comparative indifference to potash and nitrogen therefore suggested an increase of phosphoric acid and a reduction of nitrogen in the fertilizer, leaving the potash unchanged, in order that there might be a surplus of the mineral constituents as compared with the nitrogen supplied in the fertilizers. To accomplish this change the use of bran as a carrier of phosphoric acid on Plot 17 was discontinued, the quantity of phosphoric acid applied on Plots 17, 21, 23 and 24 was doubled, and the quantity of nitrogen was reduced by one-half. The fertilizing of Plot 30 was also so readjusted as to bring tankage into the comparison of nitrogen carriers.

*The Director of the station is responsible for the general plan of these experiments and for the disscussion of results. The field work at the central station has been executed under the immediate supervision of the Agriculturist of the station, in the case of the cereal and hay crops, and under that of the Horticulturist in the case of potatoes. These gentlemen have also assisted in the conduct of the work at the sub-stations. The fertilizers useds have been analyzed by the Chemist and Assistant Chemist of the station.

TABLE I: PLAN OF FERTILIZING IN 5-YEAR ROTATION.

*Fertilizers in pounds per acre.*

| Plot No. | On corn. | | | On oats. | | | On wheat. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Superphosphate. [1] | Muriate of potash. | Nitrate of soda. | Superphosphate. [1] | Muriate of potash | Nitrate of soda. | Superphosphate. [1] | Muriate of potash | Dried blood. | Nitrate of soda. [2] |
| 1 | | | | | | | | | | |
| 2 | 80 | | | 80 | | | 160 | | | |
| 3 | | 80 | | | 80 | | | 100 | | |
| 4 | | | | | | | | | | |
| 5 | | | 160 | | | 160 | | | 50 | 120 |
| 6 | 80 | | 160 | 80 | | 160 | 160 | | 50 | 120 |
| 7 | | | | | | | | | | |
| 8 | 80 | 80 | | 80 | 80 | | 160 | 100 | | |
| 9 | | 80 | 160 | | 80 | 160 | | 100 | 50 | 120 |
| 10 | | | | | | | | | | |
| 11 | 80 | 80 | 160 | 80 | 80 | 160 | 160 | 100 | 50 | 120 |
| 12 | 80 | 80 | 240 | 80 | 80 | 240 | 160 | 100 | 50 | 200 |
| 13 | | | | | | | | | | |
| 14 | 80 | 80 | 160 | | | | 160 | 100 | 50 | 120 |
| 15 | | | | | | | 160 | 100 | 50 | 120 |
| 16 | | | | | | | | | | |
| 17[3] | 160 | 80 | 80 | 160 | 80 | 80 | 160 | 100 | 25 | 60 |
| 18[4] | | | | | | | | | | |
| 19 | | | | | | | | | | |
| 20[4] | | | | | | | | | | |
| 21[3] | 145 | 75 | | 145 | 75 | | 145 | 95 | | |
| 22 | | | | | | | | | | |
| 23[3] | 150 | 80 | | 150 | 80 | | 150 | 100 | 100 | |
| 24[3] | 160 | 80 | | 160 | 80 | | 160 | 100 | | |
| 25 | | | | | | | | | | |
| 26[5] | | 80 | 150 | | 80 | 150 | | 100 | | 120 |
| 27[5] | | 80 | 160 | | 80 | 160 | | 100 | 50 | 120 |
| 28 | | | | | | | | | | |
| 29[5] | | 80 | 160 | | 80 | 160 | | 100 | 50 | 120 |
| 30[3] | 80 | 80 | | 80 | 80 | | 80 | 100 | | |
| 31 | | | | | | | | | | |
| 32 | 80 | 80 | 80 | 80 | 80 | 80 | 160 | 100 | 25 | 60 |
| 33 | 80 | 80 | 40 | 80 | 80 | 40 | 160 | 100 | 15 | 30 |
| 34 | | | | | | | | | | |
| 35 | 80 | 40 | 160 | 80 | 40 | 160 | 160 | 50 | 50 | 120 |
| 36 | 80 | 20 | 160 | 80 | 20 | 160 | 160 | 25 | 50 | 120 |
| 37 | | | | | | | | | | |
| 38[6] | | | | | | | 100 | 10 | | |
| 39[7] | | | | | | | | | | |
| 40 | | | | | | | | | | |

[1] Superphosphate as dissolved bone black previous to 1897: as acid phosphate, 1897 and since

[2] Nitrate of soda and sulphate of ammonia are applied to wheat in April; all other fertilizers in the fall

[3] Plot 17 received wheat bran as the carrier of all the phosphoric acid and half the nitrogen previous to 1899. Beginning with the spring of 1899, Plots 17, 21, 23, 24 and 30 are used in comparison of carriers of nitrogen; nitrate of soda being used on Plot 17, linseed oil meal on Plot 21, dried blood on Plot 23 sulphate of ammonia on Plot 24 and tankage on Plot 30 the quantity in each case being calculated to carry the same quantity of nitrogen as that found in 80 pounds of nitrate of soda. Previous to 1899 these plots, except No. 30, had received twice this quantity of nitrogen in the same carriers, except as stated for Plot 17 and half the quantity of phosphoric acid now given. Previous to 1899 Plot 30 had received the same mixture on both corn and wheat now given to wheat only, on Plot 38

[4] Plots 18 and 20 are top dressed with barnyard manure for corn and wheat, 8 tons per acre for each crop on Plot 18 and 4 tons for each crop on Plot 20.

[5] Plots 26, 27 and 29 are used in comparison of carriers of phosphoric acid, raw bone meal being used on Plot 26, dissolved bone black on Plot 27 and basic slag on Plot 29. These plots are compared with Plot 11 on which acid phosphate is used. Previous to 1897 dissolved bone black was used on all these plots except 27, on which acid phosphate was then used.

[6] Plot 38 receives on wheat a mixture of tankage, acid phosphate and muriate of potash, calculated to analyze 3½ to 4 per cent. "ammonia," 14 per cent. total phosphoric acid and 2½ per cent. potash

[7] Plot 39 is top-dressed for wheat with 16 tons per acre of barnyard manure.

Tables II and III show the yield of crops in this experiment, as found in the duplicate tests at Wooster and Strongsville, corn being reported for the two years, 1899 and 1900, and other crops for 1900, following the tables given in the appendix to Bulletin 110. Tables IV and V give the average yield for the seven years in which the experiment has been conducted at Wooster and for the six years at Strongsville, and Tables VI and VII give the average increase, found for these periods, from the different combinations of fertilizing materials.

The yield of corn in 1899 was reduced by drouth, especially at Strongsville The wheat crop was cut short in both tests by Hessian fly and winter killing, the destruction being almost complete at Strongsville, where it seemed to be chiefly due to the winter.

Of the seven crops of wheat grown in the Wooster test, three have yielded less than 3 bushels per acre on the unfertilized plots, while the average unfertilized yield for the seven years has been but 7¾ bushels, a result due to an impoverished soil and unfavorable seasonal conditions combined.

A glance over the columns of figures for the two tests shows that not only the unfertilized yield but the increase for fertilizers has been larger at Wooster than at Strongsville. It is difficult to account for this difference in productiveness of the two soils on the basis of chemical composition, for the analyses of these soils show that both soils contain practically the same quantity of potash, while the proportion of phosphoric acid is more than 20 per cent. greater at Strongsville than at Wooster, and the proportion of nitrogen more than 60 per cent. greater, the Strongsville soil having lain in pasture for about twenty years before this experiment began, while that at Wooster had been kept under a severe system of cropping. These differences in the chemical composition are illustrated in Table VI, which gives the pounds per acre of phosphoric acid, potash and nitrogen found in the upper foot of the two soils; the determinations having been revised by Prof. Selby and Mr. Ames since the publication of Bulletin 110.

TABLE II: YIELD OF CROPS GROWN IN 5-YEAR ROTATION AT WOOSTER.

| Plt No. | Corn (1 bushel=70 pounds.) 1899 Ear-corn. | Corn 1899 Stover. | Corn 1900. Ear-corn. | Corn 1900. Stover. | Oats. (1 bu =32 pounds) 1900. Grain. | Oats. 1900. Straw. | Wheat. (1 bu =60 pounds) 1900. Grain | Wheat. 1900. Straw. | Hay. 1900 First year. | Hay. 1900 Second year.* |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bus. | Lbs. | Bus. | Lbs. | Bus. | Lbs. | Bus. | Lbs. | Lbs. | Lbs. |
| 1 | 30.04 | 1380 | 34.25 | 1730 | 22.18 | 840 | 1.33 | 210 | 1130 | 3410 |
| 2 | 31.21 | 1360 | 48.07 | 1980 | 31.87 | 1300 | 11.83 | 940 | 1660 | 4160 |
| 3 | 23 96 | 1270 | 32.54 | 1830 | 19.37 | 730 | 1 55 | 147 | 1900 | 3990 |
| 4 | 22.89 | 1160 | 28 86 | 1570 | 17.50 | 610 | 0 83 | 120 | 1620 | 3650 |
| 5 | 25 04 | 1260 | 34.96 | 1800 | 20 00 | 770 | 2 00 | 275 | 1910 | 3520 |
| 6 | 35 64 | 1520 | 47.04 | 1970 | 40.15 | 1465 | 13,58 | 1175 | 2030 | 3770 |
| 7 | 17.79 | 960 | 28.57 | 1520 | 16.75 | 495 | 0 75 | 105 | 1190 | 3650 |
| 8 | 34 25 | 1480 | 43.68 | 2080 | 38.43 | 1590 | 12.25 | 835 | 1480 | 4000 |
| 9 | 23 57 | 1280 | 29 14 | 1670 | 18.57 | 665 | 1.42 | 175 | 1660 | 3800 |
| 10 | 22 68 | 1130 | 25 50 | 1450 | 17.19 | 550 | 1.42 | 190 | 1190 | 3530 |
| 11 | 37.93 | 1610 | 46.68 | 2170 | 43 12 | 1520 | 11.67 | 1120 | 18: 0 | 4600 |
| 12 | 41.36 | 1680 | 49.86 | 2180 | 45.16 | 2705 | 13.17 | 1140 | 2060 | 4250 |
| 13 | 27.75 | 1280 | 23.96 | 1480 | 22.03 | 895 | 0.17 | 50 | 1040 | 3590 |
| 14 | 42.50 | 1870 | 42.57 | 2000 | 35 00 | 1530 | 9.33 | 880 | 1870 | 4250 |
| 15 | 30.36 | 1400 | 33.21 | 1770 | 23.75 | 930 | 9 67 | 810 | 1610 | 4100 |
| 16 | 19.21 | 1000 | 26 64 | 1710 | 19.69 | 750 | 0 25 | 80 | 1050 | 2000 |
| 17 | 40.50 | 1640 | 48 68 | 2200 | 49.53 | 2235 | 11.67 | 950 | 1510 | 3750 |
| 18 | 36.79 | 2000 | 53 14 | 2340 | 42.34 | 1655 | 10 25 | 1145 | 2360 | 3700 |
| 19 | 26.64 | 1280 | 28.71 | 1720 | 20.62 | 880 | 0.75 | 195 | 1270 | 2900 |
| 20 | 41.32 | 1870 | 37 96 | 1950 | 34.22 | 1135 | 7 75 | 1175 | 2070 | 3250 |
| 21 | 48 32 | 1990 | 45 36 | 1990 | 51.25 | 2090 | 15.75 | 1155 | 1680 | 3700 |
| 22 | 23.29 | 1100 | 23.18 | 1460 | 17.34 | 635 | 0 58 | 100 | 1210 | 3250 |
| 23 | 42 75 | 1800 | 46.61 | 2000 | 44.37 | 1920 | 16.83 | 13: 0 | 1500 | 3950 |
| 24 | 39 86 | 1720 | 45.46 | 2010 | 46.25 | 2320 | 17.33 | 1470 | 1620 | 4000 |
| 25 | 27.14 | 1360 | 28.32 | 1540 | 20.62 | 700 | 1.25 | 165 | 1520 | 3350 |
| 26 | 34.50 | 1670 | 41.32 | 1770 | 33 44 | 1620 | 11.92 | 1075 | 1970 | 4350 |
| 27 | 34 00 | 1600 | 47.75 | 2100 | 40.62 | 1750 | 23.33 | 1870 | 1870 | 4100 |
| 28 | 18.14 | 1040 | 35.00 | 1680 | 15.00 | 370 | 3 50 | 390 | 16 0 | 3350 |
| 29 | 37 61 | 1660 | 45.68 | 2160 | 33.28 | 1255 | 21.00 | 1890 | 2130 | 3800 |
| 30 | 36.75 | 1690 | 47.11 | 2120 | 40 00 | 1420 | 21.75 | 1475 | 1640 | 3300 |

*Millet.

TABLE III: YIELD OF CROPS GROWN IN 5-YEAR ROTATION AT STRONGSVILLE.

| Plt No | Corn. | | | | Oats. | | Wheat. | | Hay 1900 |
|---|---|---|---|---|---|---|---|---|---|
| | 1899. | | 1900. | | 1900. | | 1900. | | |
| | Ear-corn. | Stover. | Ear-corn. | Stover. | Grain. | Straw. | Grain. | Straw. | First year. |
| | Bushels. | Pounds | Bushels. | Pounds. | Bushels. | Pounds. | Bus. | Lbs. | Lbs. |
| 1 | 7.57 | 865 | 16.82 | 1290 | 15.78 | 515 | .13 | 27 | 830 |
| 2 | 15.93 | 965 | 34.53 | 1560 | 26.87 | 790 | 1.42 | 130 | 1530 |
| 3 | 11.43 | 905 | 16 39 | 1420 | 15.31 | 460 | .21 | 17 | 830 |
| 4 | 10.16 | 765 | 19.21 | 1380 | 13.75 | 360 | .17 | 20 | 580 |
| 5 | 15.14 | 890 | 21.86 | 1500 | 18.28 | 615 | .29 | 22 | 740 |
| 6 | 28.43 | 1200 | 33 64 | 1800 | 37 81 | 1270 | 2.04 | 182 | 1000 |
| 7 | 28.21 | 1215 | 29.21 | 1700 | 28.75 | 1230 | .29 | 8 | 440 |
| 8 | 32.43 | 1295 | 31.00 | 1720 | 41.09 | 1435 | 2.80 | 197 | 960 |
| 9 | 26.71 | 1210 | 25.46 | 1640 | 28.75 | 1080 | 1.21 | 72 | 840 |
| 10 | 17 71 | 900 | 22 82 | 1400 | 25.62 | 900 | 1 50 | 110 | 700 |
| 11 | 25.11 | 1270 | 33.04 | 1860 | 40.62 | 1380 | 3.42 | 240 | 1720 |
| 12 | 24 00 | 1300 | 30 14 | 1940 | 38.59 | 1275 | 4 33 | 285 | 1900 |
| 13 | 17.43 | 1050 | 25 46 | 1620 | 25.62 | 910 | .87 | 62 | 1100 |
| 14 | 37.29 | 1640 | 29.53 | 1720 | 36.72 | 1345 | 3 08 | 225 | 1340 |
| 15 | 33 50 | 1570 | 25 86 | 1620 | 33.56 | 1382 | 2.46 | 222 | 980 |
| 16 | 27.86 | 1240 | 21.07 | 1540 | 30.39 | 11 7 | .83 | 55 | 780 |
| 17 | 31.36 | 1300 | 34.00 | 1680 | 46.56 | 1560 | 2.96 | 212 | 1320 |
| 18 | 36.07 | 1375 | 34.04 | 1880 | 32.19 | 1120 | 3.46 | 252 | 1400 |
| 19 | 13.21 | 1010 | 19.54 | 1390 | 18.44 | 560 | .67 | 40 | 760 |
| 20 | 21.50 | 1155 | 34 12 | 18 0 | 25 31 | 790 | 2.67 | 195 | 1360 |
| 21 | 23 86 | 1130 | 37.93 | 1980 | 40.39 | 1257 | 2.62 | 167 | 2300 |
| 22 | 14.71 | 890 | 30.68 | 1900 | 20 08 | 657 | .71 | 47 | 1400 |
| 23 | 26.00 | 1090 | 43.93 | 2340 | 42.19 | 1420 | 2.58 | 180 | 1980 |
| 24 | 27.07 | 1080 | 40.43 | 2300 | 41 45 | 1552 | 2.87 | 207 | 1720 |
| 25 | 17.29 | 880 | 32.50 | 1860 | 23.69 | 865 | .71 | 52 | 1020 |
| 26 | 27.93 | 1250 | 40.93 | 2000 | 32.11 | 1252 | 3.12 | 212 | 1440 |
| 27 | 21.71 | 1110 | 43.71 | 2040 | 36.31 | 1357 | 2.71 | 227 | 1320 |
| 28 | 19.36 | 1000 | 32.29 | 1800 | 24 22 | 925 | .58 | 40 | 620 |
| 29 | 30 00 | 1290 | 39.82 | 2220 | 35.94 | 1370 | 2.46 | 177 | 1380 |
| 30 | 36.36 | 1450 | 49.39 | 2320 | 43 91 | 1625 | 2.96 | 187 | 1340 |
| 31 | 16.71 | 935 | 29.82 | 1840 | 25.94 | 990 | .17 | 5 | 620 |
| 32 | 26.43 | 1320 | 42.21 | 2240 | 40.47 | 1485 | 2.00 | 150 | 1140 |
| 33 | 23.64 | 1140 | 47.39 | 2320 | 37.27 | 1307 | 2 58 | 195 | 1040 |
| 34 | 14.64 | 890 | 25.50 | 1660 | 19.37 | 680 | .96 | 62 | 640 |
| 25 | 24 79 | 1090 | 35 18 | 1980 | 35.70 | 1137 | 3.37 | 232 | 1300 |
| 36 | 24.07 | 1080 | 40 04 | 2300 | 36.09 | 1045 | 4.00 | 260 | 1460 |
| 37 | 16.00 | 925 | 30.11 | 1680 | 21.01 | 657 | 1.17 | 80 | 760 |
| 38 | 24.79 | 1150 | 36.68 | 2040 | 25.78 | 925 | 2·71 | 177 | 1380 |
| 39 | 21.50 | 1090 | 33.96 | 2020 | 24.30 | 892 | 2.33 | 230 | 940 |
| 40 | 17.57 | 855 | 27.75 | 1660 | 22.58 | 727 | .67 | 40 | 960 |

TABLE IV: AVERAGE YIELD OF CROPS GROWN IN 5-YEAR ROTATION AT WOOSTER

| Pl't No. | Corn 7-year average. | | Oats 7-year average. | | Wheat 7-year average. | | Hay. | |
|---|---|---|---|---|---|---|---|---|
| | Ear-corn. | Stover | Grain. | Straw. | Grain. | Straw. | 1st year. 6-year average. | 2d year 5-year average. |
| | Bushels | Pounds | Bushels. | Pounds. | Bushels. | Pounds | Pounds | Pounds. |
| 1 | 31.95 | 1597 | 30.90 | 1144 | 7.10 | 795 | 1563 | 2714 |
| 2 | 37.06 | 1636 | 38.04 | 1364 | 12.14 | 1320 | 2043 | 2882 |
| 3 | 33.02 | 1654 | 32.52 | 1169 | 9.48 | 1053 | 1928 | 3014 |
| 4 | 20.56 | 1553 | 30.66 | 1172 | 8.38 | 954 | 1853 | 2660 |
| 5 | 33 84 | 1633 | 33.93 | 1237 | 9.84 | 1160 | 1972 | 2842 |
| 6 | 42 75 | 1797 | 42 08 | 1565 | 16.49 | 1872 | 2670 | 3116 |
| 7 | 31.12 | 1489 | 30 11 | 1089 | 8.10 | 938 | 1742 | 2568 |
| 8 | 39 79 | 1817 | 39.87 | 1508 | 14.76 | 1453 | 2392 | 2850 |
| 9 | 31.10 | 1613 | 3 .90 | 1195 | 10 05 | 1107 | 2158 | 2680 |
| 10 | 28.40 | 1 416 | 29.36 | 1059 | 8 03 | 867 | 1822 | 2402 |
| 11 | 41 58 | 1841 | 45.68 | 1800 | 19.59 | 2211 | 2765 | 3246 |
| 12 | 42.37 | 1854 | 46 97 | 2087 | 20.37 | 2303 | 2907 | 2942 |
| 13 | 29.82 | 1511 | 30.57 | 1178 | 7 80 | 846 | 1833 | 2476 |
| 14 | 41.41 | 1927 | 37.44 | 1506 | 17.04 | 1999 | 2693 | 3082 |
| 15 | 32.10 | 1660 | 30.22 | 1094 | 16.03 | 1795 | 2268 | 2846 |
| 16 | 27.43 | 1546 | 28.45 | 1065 | 6 69 | 728 | 1640 | 2424 |
| 17 | 38.61 | 1836 | 42 05 | 1691 | 13 65 | 1475 | 2365 | 2898 |
| 18 | *42.14 | 2091 | 39.03 | 1479 | 12 76 | 1571 | 2943 | 3520 |
| 19 | 31.56 | 1620 | 29.28 | 1074 | 7.05 | 749 | 1758 | 2512 |
| 20 | 39.12 | 1924 | 34.32 | 1303 | 11.23 | 1363 | 2475 | 3082 |
| 21 | 40.29 | 1914 | 42.03 | 1702 | 18.61 | 2065 | 2385 | 2790 |
| 22 | 27.48 | 1476 | 28 55 | 1072 | 7.14 | 771 | 1595 | 2258 |
| 23 | 39.68 | 1867 | 43.08 | 1691 | 17 27 | 1837 | 2363 | 2824 |
| 24 | 41.12 | 1953 | 45.77 | 1925 | 18.25 | 1955 | 2342 | 2784 |
| 25 | 30.45 | 1600 | 29.73 | 1169 | 8 49 | 895 | 1815 | 2556 |
| 26 | 38.79 | 1927 | 42.71 | 1619 | 17.57 | 1969 | 2567 | 3358 |
| 27 | 40.68 | 1919 | 45.63 | 1792 | 20.08 | 2150 | 2330 | 3268 |
| 28 | 33.10 | 1651 | 31.20 | 1131 | 8 84 | 908 | 1760 | 2836 |
| 29 | 43.25 | 2046 | 43.59 | 1678 | 19.43 | 2108 | 2448 | 3686 |
| 30 | 41.79 | 1896 | 39.17 | 1446 | 16.06 | 1600 | 2323 | 3538 |

* 6-year ave age.

TABLE V: AVERAGE YIELD OF CROPS GROWN IN 5-YEAR ROTATION AT STRONGSVILLE.

| Pl't No. | Corn. 6-year average. | | Oats. 5-year average. | | Wheat. 4-year average. | | Hay. 1st year. 4-year average. |
|---|---|---|---|---|---|---|---|
| | Ear corn. | Stover. | Grain. | Straw. | Grain. | Straw. | |
| | Bushels | Pounds. | Bushels. | Pounds | Bushels. | Pounds. | Pounds. |
| 1 | 23.50 | 1307 | 29.39 | 1176 | 4.32 | 387 | 1135 |
| 2 | 28.61 | 1322 | 38.95 | 1475 | 10 62 | 1206 | 1915 |
| 3 | 21 92 | 1244 | 30.08 | 1099 | 4.56 | 402 | 1132 |
| 4 | 20.42 | 1191 | 27.87 | 978 | 5.38 | 537 | 987 |
| 5 | 22.24 | 1255 | 29.03 | 1116 | 5 02 | 484 | 1405 |
| 6 | 30.12 | 1387 | 43 51 | 1538 | 14.05 | 1453 | 1960 |
| 7 | 24.75 | 1378 | 31 19 | 1132 | 5.09 | 488 | 1550 |
| 8 | 29.10 | 1292 | 43.03 | 1572 | 11.62 | 1122 | 2065 |
| 9 | 25.86 | 1351 | 34.73 | 1388 | 7.02 | 237 | 1585 |
| 10 | 24.48 | 1318 | 33 73 | 1276 | 5 33 | 542 | 1250 |
| 11 | 34 76 | 1615 | 46.86 | 1863 | 15.17 | 1431 | 2122 |
| 12 | 33.18 | 1648 | 47 67 | 1907 | 18.74 | 1974 | 2005 |
| 13 | 27.05 | 1415 | 34 92 | 1422 | 5.53 | 532 | 1402 |
| 14 | 34.71 | 1690 | 40.06 | 1553 | 16 56 | 1634 | 2200 |
| 15 | 28.26 | 1466 | 34 09 | 1318 | 14.57 | 1403 | 1865 |
| 16 | 28.82 | 1562 | 33.59 | 1231 | 6.04 | 541 | 1397 |
| 17 | 33.22 | 1611 | 45 19 | 1771 | 10.26 | 952 | 2040 |
| 18 | 37.47 | 1749 | 37.80 | 1391 | 14 14 | 1384 | 2200 |
| 19 | 25 40 | 1527 | 29 93 | 1076 | 3.87 | 300 | 1232 |
| 20 | 33.58 | 1692 | 35 14 | 1360 | 10.56 | 980 | 1945 |
| 21 | 31.29 | 1692 | 45.40 | 1927 | 12.70 | 1261 | 2330 |
| 22 | 26 74 | 1606 | 34.22 | 1407 | 6.32 | 605 | 1665 |
| 23 | 34.54 | 1697 | 48 03 | 2167 | 14.19 | 1454 | 2612 |
| 24 | 33 99 | 1775 | 47.46 | 2105 | 14 65 | 1520 | 2405 |
| 25 | 27.11 | 1590 | 31.97 | 1395 | 5.58 | 560 | 1565 |
| 26 | 32 56 | 1773 | 44.47 | 1756 | 15.95 | 1682 | 2437 |
| 27 | 32.78 | 1735 | 44.43 | 1809 | 13.53 | 1310 | 2060 |
| 28 | 25.39 | 1488 | 30.62 | 1127 | 5.97 | 567 | 1430 |
| 29 | 34.81 | 1707 | 43.61 | 1703 | 16.95 | 1663 | 2320 |
| 30 | 40.00 | 1763 | 42.67 | 1638 | 14.03 | 1385 | 2430 |
| 31 | 25.81 | 1489 | 29.28 | 1200 | 4.47 | 429 | 1340 |
| 32 | 31.34 | 1633 | 42.41 | 1692 | 13.69 | 1346 | 2160 |
| 33 | 32.49 | 1518 | 41.22 | 1726 | 11.89 | 1000 | 2215 |
| 34 | 22.41 | 1358 | 28.00 | 1114 | 5.30 | 522 | 1092 |
| 35 | 30 49 | 1531 | 41.92 | 1714 | 14.41 | 1379 | 1952 |
| 36 | 34 81 | 1732 | 41.70 | 1608 | 15.08 | 1496 | 2180 |
| 37 | 26.65 | 1377 | 28.39 | 1146 | 5.18 | 458 | 1232 |
| 38 | 29.08 | 1520 | 30.12 | 1242 | 13.22 | 1325 | 2170 |
| 39 | 26.25 | 1416 | 30.01 | 1131 | 9.99 | 928 | 1755 |
| 40 | 24.82 | 1355 | 28.14 | 1085 | 5.37 | 478 | 1252 |

TABLE VI: POUNDS PER ACRE OF CHIEF FERTILIZING CONSTITUENTS FOUND IN WOOSTER AND STRONGSVILLE SOILS.

| Fertilizing constituents. | Wooster. | Strongsville. |
|---|---|---|
| Phosphoric acid | 3,381 | 4,133. |
| Potash | 7,574 | 7,126. |
| Nitrogen | 2,845 | 4,557. |

So far as these chief constituents of fertility are concerned, the Strongsville soil is decidedly richer than that at Wooster. Whether its lack of productiveness is due to a lack of proper balance between the lime and other constituents, or merely to its physical condition, this soil being a much stiffer clay than that at Wooster, remains for further investigations to determine.

In order to reduce the results of these tests to a common denominator, Tables VII and VIII have been compiled, in which are given the average increase for each application of fertilizers for each crop and the total weight and value of increase for an average rotation, ear-corn being valued at 50 cents per cental or 35 cents per bushel; oats at 80 cents per cental or 25.6 cents per bushel; wheat at $1.10 per cental or 66 cents per bushel; corn stover at $3.00 per ton; straw at $2.00 per ton and mixed hay at $8.00 per ton.

Comparing the average results of the two tests on this basis we note that the increase from acid phosphate used alone (Plot 2) is apparently greater at Strongsville than at Wooster. The increase from muriate of potash and nitrate of soda, whether used alone or in combination with each other, but without phosphoric acid (Plots 3, 5 and 9) is very small in both cases, but especially so at Strongsville. When either of these is combined with phosphoric acid (Plots 6 and 8) there is a marked increase at Wooster over the yield shown on Plot 2, this increase being greater for the combination of phosphoric acid and nitrogen than for that of phosphoric acid and potash; but at Strongsville the addition of potash to phosphoric acid produces no further increase, and that of nitrogen a comparatively small advance. When all these are used together (Plot 11) there is a further increase, which is much greater at Wooster than at Strongsville.

TABLE VII: AVERAGE INCREASE* OF CROPS GROWN IN 5-YEAR ROTATION AT WOOSTER.

| Pl't No. | Corn. 7-year average. | | Oats. 7-year average. | | Wheat. 7-year average. | | Hay. | | Total weight of increase for one rotation. | Total value of increase. | Pl't No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ear-corn. | Stover | Grain. | Straw. | Grain. | Straw. | 1st year. 6-year average. | 2d year. 5-year average. | | | |
| | Bus. | Lbs. | Bus. | Lbs. | Bus. | Lbs. | Lbs. | Lbs. | Lbs. | | |
| 2 | 5.57 | 53 | 7.22 | 210 | 4 61 | 471 | 383 | 186 | 2201 | $10 60 | 2 |
| 3 | 2.00 | 87 | 1.78 | 6 | 1 52 | 151 | 172 | 336 | 1040 | 4 48 | 3 |
| 5 | 3.09 | 101 | 3.45 | 92 | 1.55 | 211 | 155 | 213 | 1191 | 4 83 | 5 |
| 6 | 11.82 | 287 | 11.79 | 448 | 8 30 | 928 | 891 | 517 | 4772 | 20 05 | 6 |
| 8 | 9.57 | 353 | 10.01 | 430 | 6.68 | 538 | 623 | 337 | 3672 | 15 66 | 8 |
| 9 | 1.79 | 173 | 2 29 | 126 | 2.00 | 216 | 363 | 225 | 1421 | 5 48 | 9 |
| 11 | 12.70 | 393 | 15 92 | 701 | 11.64 | 1351 | 939 | 819 | 6299 | 25 86 | 11 |
| 12 | 13 02 | 375 | 16.81 | 948 | 12.49 | 1450 | 1077 | 491 | 6539 | 26 32 | 12 |
| 14 | 12.38 | 404 | 7.58 | 365 | 9.61 | 1192 | 924 | 623 | 5194 | 20 93 | 14 |
| 15 | [1]6.90 | [1]155 | [3]3 80 | [3]170 | 8.97 | 1028 | 564 | 405 | 3465 | 14 62 | 15 |
| 17 | [2]11.08 | [2]265 | 13.33 | 622 | 6.84 | 740 | 685 | 445 | 4369 | 17 88 | 17 |
| 18 | [2]12.98 | [2]496 | [2]8.81 | [2]427 | 5.83 | 829 | 1224 | 1037 | 5554 | 21 69 | 18 |
| 20 | 8.92 | 352 | 5.28 | 230 | 4 15 | 607 | 771 | 655 | 3657 | 14 27 | 20 |
| 21 | 11.44 | 390 | 13.24 | 629 | 11.50 | 1301 | 736 | 447 | 5418 | 22 22 | 21 |
| 23 | 11.21 | 350 | 14.14 | 497 | 9.68 | 1025 | 695 | 467 | 4852 | 20 62 | 23 |
| 24 | 11.66 | 394 | 16.43 | 789 | 10.21 | 1102 | 600 | 327 | 5167 | 21 22 | 24 |
| 26 | 7.46 | 310 | 12.49 | 463 | 8.96 | 1070 | 770 | 709 | 4782 | 19 64 | 26 |
| 27 | 8 46 | 284 | 14.92 | 648 | 11.35 | 1246 | 553 | 525 | 5006 | 20 89 | 27 |
| 29 | 10.14 | 394 | 12.39 | 547 | 10.59 | 1200 | 688 | 850 | 5420 | 22 18 | 29 |
| 30 | 8.68 | 244 | 7.97 | 315 | 7.21 | 692 | 563 | 702 | 3812 | 16 26 | 30 |

*In this and subsequent tables the increase for the fertilized plots has been calculated on the assumption that if the yields of two neighboring unfertilized plots, 1 and 4, for example, were twenty-five and twenty eight bushels, respectively, the unaided yield of the fertilized plots between, 2 and 3, would have been twenty-six and twenty-seven bushels.

[1]4-year average.

[2]6-year average.

[3]3-year average.

TABLE VIII: AVERAGE INCREASE OF CROPS GROWN IN 5-YEAR ROTATION AT STRONGSVILLE.

| Pl't No. | Corn. 6-year average. | | Oats. 4-year average. | | Wheat. 4-year average. | | Hay. 1st year. 4-year average. | Total weight of increase for one rotation. | Total value of increase. | Pl't No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ear-corn | Stover | Grain. | Straw. | Grain. | Straw | | | | |
| | Bus. | Lbs. | Bus. | Lbs. | Bus. | Lbs. | Lbs. | Lbs. | | |
| 2 | 6.14 | 54 | 10.07 | 365 | 5.94 | 769 | 829 | 3125 | $13 90 | 2 |
| 3 | .47 | 14 | 1.70 | 55 | —46 | —85 | 96 | 139 | 0 66 | 3 |
| 5 | .38 | 2 | .05 | 87 | —.26 | —37 | 230 | 195 | 0 94 | 5 |
| 6 | 6 81 | 71 | 13.43 | 458 | 8.86 | 949 | 598 | 3515 | 15 58 | 6 |
| 8 | 4.44 | —66 | 10.97 | 395 | 6.44 | 616 | 615 | 2608 | 11 97 | 8 |
| 9 | 1.29 | 12 | 1.85 | 167 | 1.76 | 214 | 235 | 883 | 3 43 | 9 |
| 11 | 9.42 | 264 | 12.72 | 545 | 9.77 | 892 | 822 | 4105 | 17 76 | 11 |
| 12 | 6 98 | 266 | 13.14 | 537 | 13.27 | 1439 | 653 | 4600 | 19 54 | 12 |
| 14 | 7.07 | 226 | 5.59 | 194 | 10.87 | 1098 | 799 | 3643 | 15 91 | 14 |
| 15 | [1]6.22 | [1]223 | [3]4.56 | [3]327 | 8.73 | 864 | 468 | 2987 | 12 49 | 15 |
| 17 | 5.54 | 61 | 12.82 | 592 | 4 97 | 489 | 697 | 2935 | 12 46 | 17 |
| 18 | 10.93 | 212 | 6 64 | 265 | 9.55 | 1003 | 911 | 3941 | 17 04 | 18 |
| 20 | 6.86 | 111 | 3.38 | 174 | 5.88 | 578 | 568 | 2372 | 10 34 | 20 |
| 21 | 5 86 | 196 | 12.61 | 630 | 7.20 | 757 | 809 | 3637 | 14 95 | 21 |
| 23 | 7.68 | 95 | 14.56 | 764 | 8.11 | 863 | 981 | 4194 | 17 46 | 23 |
| 24 | 7.00 | 179 | 14.75 | 706 | 8.82 | 946 | 806 | 4128 | 18 18 | 24 |
| 26 | 6.02 | 217 | 12.95 | 450 | 10.24 | 1020 | 917 | 4053 | 17 62 | 26 |
| 27 | 6.82 | 213 | 13.37 | 592 | 7.69 | 746 | 585 | 3502 | 14 93 | 27 |
| 29 | 9 28 | 218 | 13.44 | 552 | 11.48 | 1142 | 920 | 4601 | 19 97 | 29 |
| 30 | 14.32 | 274 | 12 94 | 463 | 9.06 | 910 | 1060 | 4667 | 20 30 | 30 |
| 32 | [2]9.23 | [2]222 | 13.55 | 521 | 8.94 | 886 | 902 | 4147 | 17 94 | 32 |
| 33 | [2]10.23 | [2]184 | 12.79 | 583 | 6 86 | 509 | 1040 | 3853 | 16 90 | 33 |
| 35 | [2]6.67 | [2]166 | 13.79 | 590 | 9 15 | 878 | 813 | 3904 | 16 87 | 35 |
| 36 | [2]9.57 | [2]361 | 13.45 | 473 | 9.86 | 1017 | 994 | 4537 | 19 31 | 36 |
| 38 | [1]7.76 | [1]307 | [3]4.28 | [3]245 | 7.97 | 861 | 931 | 3505 | 14 37 | 38 |
| 39 | [1]4.93 | [1]282 | [3]2.24 | [3]188 | 4 68 | 457 | 509 | 2133 | 8 49 | 39 |

[1]2-year average.
[2]5-year average.
[3]1-year only.

It appears, therefore, that while the Strongsville soil contains a much larger quantity of phosphoric acid than that in the Wooster test, yet the effect of additions of phosphoric acid is quite as marked at Strongsville as at Wooster. Potash seems to have practically no effect at Strongsville, when used alone or in combination with phosphoric acid only, but when phosphoric acid and nitrogen have both been supplied, potash produces a small additional increase. At Wooster, however, although the effect of potash, used alone or with phosphoric acid, is still relatively small, yet it is much greater than at Strongsville. In both tests the effect of the complete fertilizer, containing phosphoric acid, potash and nitrogen, all three, is decidedly greater than that of any partial fertilizer, but the additional increase where nitrogen is added, either to phosporic acid alone (Plot 6) or to phosphoric acid and potash combined (Plot 11) appears to be considerably greater at Wooster than at Strongsville.

The limit of economical use of nitrogen appears to be reached on Plot 11, as the additional quantity of nitrate of soda added to Plot 12 produces but an insignificant additional increase of crop.

When we turn to the financial aspects of the problem under investigation, we find that although a very much larger increase of crop has been produced by the complete fertilizer, used on Plots 11 and 12, than on any of the plots receiving partial fertilizers only, yet the cost of the complete fertilizer has been so great as to largely reduce the net profit. This point is illustrated in Table IX, which gives the total quantity and cost of fertilizers applied to several of the plots during the course of a five-year rotation, with the value of produce and net gain or loss from the operation.

TABLE IX: TOTAL QUANTITY AND COST OF FERTILIZERS AND VALUE OF INCREASE FOR ONE ROTATION.

| Pl't No. | Fertilizers. | Quantity per acre. | Cost per acre. | Value of increase per acre. | | Net gain or loss (—) per acre. | |
|---|---|---|---|---|---|---|---|
| | | | | Wooster | Strongsville. | Wooster | Strongsville. |
| | | Pounds | | | | | |
| 2 | Acid phosphate | 320 | $2 40 | $10 60 | $13 90 | $8 20 | $11 50 |
| 3 | Muriate of potash | 260 | 6 10 | 4 48 | 0 66 | —1 62 | —5 44 |
| 5 | Nitrate of soda | 480 | 10 80 | 4 84 | 0 94 | —5 96 | —9 86 |
| 6 | Acid phosphate and nitrate soda | 800 | 13 20 | 20 05 | 15 58 | 6 85 | 2 38 |
| 8 | Acid Phos and muriate potash | 580 | 8 50 | 15 66 | 11 97 | 7 16 | 3 47 |
| 9 | Nitrate soda and muriate potash | 740 | 16 90 | 5 48 | 3 43 | —10 42 | —12 47 |
| 11 | Complete fertilizer | 1,060 | 19 30 | 25 86 | 17 76 | 6 56 | —1 54 |
| 12 | Complete fertilizer | 1,220 | 22 90 | 26 32 | 19 54 | 3 42 | —3 36 |
| 14 | Com. Fert. on corn & wheat only | 740 | 13 20 | 20 93 | 15 91 | 7 73 | 2 71 |
| 15 | Com. fertilizer on wheat only | 420 | 7 10 | 14 62 | 12 49 | 7 52 | 5 39 |
| 18 | Barnyard manure | 16,000 | ? | 21 69 | 17 01 | ..... | ..... |
| 20 | Barnyard manure | 8,000 | ? | 14 27 | 10 34 | ..... | ..... |

In the above table the cost of the different applications of fertilizers is calculated at the prices at which the different materials could be bought at retail in March, 1901, freight paid to Ohio, namely: acid phosphate, 16 per cent. available, $15.00 per ton; muriate of potash, $47.00 per ton and nitrate of soda, $45.00 per ton; these prices being equivalent to $4\frac{3}{4}$ cents per pound for available phosphoric acid, $4\frac{1}{2}$ cents for potash and less than 12 cents for "ammonia."

This table shows that a pecuniary loss has resulted in every instance from the use of nitrate of soda and muriate of potash in the absence of a carrier of phosphoric acid, whether they were used separately or combined. When nitrate of soda has been added to acid phosphate there has been a considerable gain in total value of increase, but the net profit is smaller than that from acid phosphate alone. This is also true where muriate of potash is added to acid phosphate in the Wooster test, but not at Strongsville. When both nitrate of soda and muriate of potash have been added a very large increase of crop results, and the

financial loss which follows their combined use without phosphoric acid is turned into a small profit at Wooster, although the cost of the fertilizer is still above the value of the increase at Strongsville. When the distance between applications is increased, however, there appears to be a more complete utilization of the plant food supplied in the fertilizers, and at Wooster the net profit becomes nearly as great as that found after acid phosphate alone, although the fertilizer has cost three to five times as much.

The increased yield when nitrogen and potash are added to phosphoric acid is evidence that there is a deficiency of these substances, in available condition, in both soils; the point to be determined is how far we may go with economy in the addition of nitrogen and potash bearing materials to our fertilizers. On this point we get a suggestion from a study of the results obtained on Plot 30. Previous to 1899 this plot received the same quantity of phosphoric acid as the other plots of the test, but a considerably smaller quantity each of potash and nitrogen, the fertilizer being mixed from tankage, acid phosphate and muriate of potash, in such proportions as to carry about 3½ per cent. ammonia, 10 to 12 per cent. phosphoric acid and 2½ per cent. potash. The following table shows the effect of a fertilizer of this character, as compared with acid phosphate used alone, during the five-year period, 1894–1898.

TABLE X—COMPARISON OF ACID PHOSPHATE WITH COMPLETE FERTILIZERS.

| Plot No. | Fertilizer. | Cost of Fertilizers. | Value of Increase. | Net Gain. |
|---|---|---|---|---|
| | WOOSTER TEST. | | | |
| 2 | Acid phosphate alone..... | $2 40 | $7 78 | $5 38 |
| 30 | Complete fertilizer..... | 4 10 | 14 29 | 10 19 |
| | STRONGSVILLE TEST. | | | |
| 2 | Acid phosphate alone..... | 2 40 | 13 35 | 10 95 |
| 30 | Complete fertilizer..... | 4 10 | 20 29 | 16 19 |

It appears from the above table that the net gain has been increased by from nearly 50 to more than 90 per cent. by the addition to the acid phosphate of small quantities of materials carrying nitrogen and potash.

In the Strongsville test there is as yet no conclusive evidence that the reduction of the nitrogen on Plots 32 and 33, or of the potash on Plots 35 and 36, is having any effect on the total yield. The lowest quantity of nitrogen or potash, as used on these plots, is considerably above the quantity of either used on Plot 30 previous to 1899.

During the first five years of the test the lengthening of the periods between applications of fertilizers on Plots 14 and 15, as compared with Plot 11, seemed at Wooster, as it still seems at Strongsville, to produce more economical results; as, although the total yield was much reduced

by the reduction of the total quantity of fertilizers applied during the rotation, the net gain was considerably increased. Later results at Wooster, however, indicate a gradual approach to uniform utilization of the plant food, whether applied only to one, to two, or to all the cereal crops of the rotation.

The increase on the plots receiving barnyard manure has amounted in value to from $1.35 to $1.78 per ton of manure at Wooster and to from $1 06 to $1.27 per ton at Strongsville. Or, if we compare Plots 18 and 20 with Plots 14 and 15, (Table IX) the 24 tons of manure used on Plots 18 and 20 combined has produced an increase practically equal to that produced by the $20 worth of fertilizers used on Plots 14 and 15 combined.

The clover crops grown in this rotation have been very light, only one crop at Wooster and none at Strongsville having reached a ton to the acre on the average of the unfertilized plots. A fair stand has usually been obtained, but the plant has not proved strong enough to endure the winter. The crop of 1898–9 at Wooster was so severely injured by the winter that it was plowed under in the spring and soy beans were grown instead. Omitting this crop, the average unfertilized yield of clover has been 1560 pounds at Wooster and 1320 pounds at Strongsville. This yield has been increased on the average of the seven plots receiving fertilizers similar in quantity and composition to the dressing applied to Plot 11 to 2457 pounds at Wooster and 2327 pounds at Strongsville, and by the barnyard manure applied to Plot 18 to 2943 pounds at Wooster and 2200 pounds at Strongsville.

The timothy has prospered better than the clover at Wooster, the average yields of the four crops harvested being 2084 pounds for the average of the unfertilized plots, 2625 pounds for the average of the plots receiving complete fertilizers, and 3475 pounds for the manured plot. At Strongsville the timothy has been so completely choked out by the spiked oat grass, or "poverty grass" (*Danthonia spicata*), which is the worst weed pest on that soil, that only one attempt has been made to harvest it.

### FERTILIZERS ON CROPS GROWN IN CONTINUOUS CULTURE.

During the period over which the experiments just described have been in progress the three cereal crops, corn, oats and wheat, have each been grown continuously on the same land at Wooster, on soil of the same character as that devoted to the rotation test. The plan and the results of this experiment are given in Table XI.

TABLE XI: FERTILIZERS ON CROPS GROWN IN CONTINUOUS CULTURE.

| Crop and Pl't No. | Fertilizers per acre. | | | Yield and increase per acre. | | | | | | Weight of average increase | Value of average increase. | Cost of fertilizers. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1900 yield. | | 7-year average. | | | | | | |
| | | | | | | Yield | | Increase. | | | | |
| | Superphosphate. | Muriate of potash | Nitrate of soda. | Grain. | Straw | Grain. | Straw. | Grain. | Straw. | | | |
| Corn. | Pounds | Pounds | Pounds | Bush'ls | Pounds | Bush'ls | Pounds | Bush'ls | Pounds | Pounds | | |
| 1 | ..... | ..... | ..... | 28.75 | 1,480 | 28.21 | 1,396 | ..... | ..... | ..... | ..... | ..... |
| 2 | 160 | 100 | 160 | 53.11 | 2,280 | 45.70 | 2,044 | 17.97 | 657 | 1,915 | $7 27 | $7 15 |
| 3 | 60 | 30 | 160 | 43 00 | 1.760 | 39 17 | 1,733 | 11.91 | 356 | 1,140 | 4 70 | 4 76 |
| 4 | ..... | ..... | ..... | 24.00 | 1,350 | 26.78 | 1,3 7 | ..... | ..... | ..... | ..... | ..... |
| 5 | | ..... | ..... . | 37.86 | 1,800 | 35 62 | 1,641 | 9.79 | 310 | 995 | 3 89 | ..... |
| 6 | | ..... | ..... | 48.39 | 2,100 | 42 88 | 1,916 | 17.99 | 620 | 1,879 | 7 23 | ..... |
| 7 | ..... | ..... | ..... | 22 32 | 1,270 | 23 94 | 1,260 | ..... | ..... | ..... | ..... | ..... |
| 8 | 160 | 100 | 320 | 58 18 | 2,430 | 46 66 | 2,084 | 24 21 | 829 | 2,524 | 9 72 | 10 75 |
| 9 | 120 | 60 | 320 | 55 32 | 2,400 | 44.63 | 1,917 | 23.66 | 767 | 2,423 | 9 43 | 9 55 |
| 10 | ..... | ..... | ..... | 16 68 | 1,000 | 19.48 | 1,096 | ..... | ..... | .. ..... | ..... | ..... |
| Oats. | | | | | | | | | | | | |
| 1 | ..... | ..... | ..... | 18.90 | 635 | 25.33 | 821 | ..... | ..... | ..... | ..... | ..... |
| 2 | 160 | 100 | 160 | 40 62 | 1,960 | 42 56 | 1,738 | 16.58 | 863 | 1,393 | 5 11 | 7 15 |
| 3 | 55 | 50 | 160 | 37.19 | 1,760 | 39.37 | 1,479 | 12 73 | 550 | 957 | 3 81 | 5 20 |
| 4 | ..... | ..... | ..... | 21.25 | 800 | 27 29 | 983 | ..... | ..... | ..... | ..... | ..... |
| 5 | | ..... | ..... | 29.37 | 1,080 | 30.77 | 1,020 | 3 46 | 19 | 130 | 0 90 | ..... |
| 6 | | ..... | ..... | 35.47 | 1,615 | 35.73 | 1,345 | 8 41 | 324 | 593 | 2 48 | ..... |
| 7 | ... .. | ..... | ..... | 22.34 | 885 | 27 34 | 1,039 | ..... | ..... | ..... | ..... | ..... |
| 8 | 160 | 100 | 320 | 47 34 | 2,635 | 50 74 | 2,248 | 22 96 | 1,202 | 1,937 | 7 08 | 10 75 |
| 9 | 110 | 100 | 320 | 48 12 | 2,300 | 48 97 | 2,099 | 20 77 | 1,047 | 1,712 | 6 36 | 10 40 |
| 10 | ..... | ..... | ..... | 25.00 | 810 | 28.64 | 1,058 | ..... | .... ... | ..... | ..... | ..... |
| Wh't | | | | | | | | | | | | |
| 1 | ..... | . ..... | ..... | 2 08 | 305 | 8.24 | 1,051 | ..... | ..... | ..... | ..... | ..... |
| 2 | 160 | 100 | 160 | 18,00 | 1,620 | 19.31 | 2,103 | 11.10 | 1 117 | 1,783 | 8 44 | 7 15 |
| 3 | 45 | 30 | 160 | 8.83 | 830 | 14 45 | 1,517 | 6.28 | 596 | 973 | 4 74 | 4 65 |
| 4 | ..... | ..... | ..... | 2 50 | 315 | 8 14 | 857 | ..... | ..... | ..... | ..... | ..... |
| 5 | | ..... | ..... | 8.58 | 815 | 11.84 | 1,302 | 3 72 | 439 | 662 | 2 89 | ..... |
| 6 | ** | ..... | ..... | 14.17 | 1,310 | 14 84 | 1,634 | 6 72 | 765 | 1,168 | 5 20 | ..... |
| 7 | ..... | ..... | ..... | 2.92 | 305 | 8.10 | 875 | ..... | ..... | ..... | ..... | ..... |
| 8 | 160 | 100 | 320 | 16 16 | 1,590 | 20 31 | 2,362 | 12 30 | 1,484 | 2,222 | 9 60 | 10 75 |
| 9 | 90 | 60 | 320 | 13.33 | 1,270 | 17.88 | 1,968 | 9.97 | 1,086 | 1,684 | 7 67 | 9 30 |
| 10 | ..... | ..... | ..... | 2 50 | 290 | 7.83 | 886 | ..... | ..... | ..... | ..... | ..... |

*The cost of fertilizers here given is based upon the rate at which acid phosphate, muriate of potash and nitrate of soda may be bought at retail. If the cost were based upon the rate at which phosphoric acid potash and nitrogen are sold in ready mixed fertilizers it would be much greater, as shown in Bulletin 110, page 60

The chief objects of this experiment are to obtain light on the capacity of the different crop plants to utilize the plant food given them in fertilizers; to study the effect of supplying plant food in the proportion indicated by chemical analysis, and to compare barnyard manure with chemical fertilizers of similar composition.

In this test Plots 3 and 9 receive nitrogen, phosphoric acid and potash in approximately the same ratio to each other in which they are found by analysis of the crops, while the ratio of phosphoric acid and potash to nitrogen is increased on Plots 2 and 8. Plot 9 receives twice the quantity of each fertilizing constituent given to Plot 3, while on

Plot 8 the nitrogen is twice that given to Plot 2, the phosphoric acid and potash remaining unchanged. The fertilizers applied to Plots 3 and 9 approximate in quantity of essential constituents and their ratio to each other the dressings of barnyard manure given to Plots 5 and 6.

Taking the corn crop, it will be seen that the value of the increase practically covers the cost of the fertilizer on Plots 3 and 9, notwithstanding the very large ratio of nitrogen to phosphoric acid and potash in the dressing of these plots (approximately, 12 per cent. "ammonia," 4 per cent. phosphoric acid and 6 per cent. potash) the increase being proportionate to the quantity of fertilizer given. The increase of phosphoric acid and potash, on Plot 2, changing the nitrogen ratio to the equivalent of 7 per cent. ammonia, produces a slight but favorable effect upon the ratio of value of product to cost of fertilizer, the total quantity of fertilizer remaining below that given to Plot 9; but where the application given to Plot 9 is increased by the addition of phosphoric acid and potash, (on Plot 8) the cost of the fertilizer exceeds the value of the increase. The effectiveness of the barnyard manure, pound per pound of essential constituents contained, is somewhat below that of the chemical fertilizers, but the five tons of manure applied to Plot 6 has produced an increase practically equivalent to that given by the fertilizers applied to Plot 2, and costing $7.15, which would indicate a relative value of $1.43 per ton of manure.

In the oats crop the cost of the fertilizers has invariably exceeded the value of the increase, the excess being greater on the heavily fertilized plots. If we count straw at $3.00 per ton, it has cost 34½ cents to produce a bushel of oats by the fertilizers used on Plot 3, 35⅓ cents on Plot 2, 39 cents on Plot 8 and 42 cents on Plot 9. In the case of the manured plots, the increase of oats is relatively larger on Plot 6 than on Plot 5; but on Plot 6 the total weight of increase is less than one-third that found on the similarly treated corn plot, and its value bears nearly the same proportion as its weight.

In the wheat crop the value of the increase found on Plot 3 slightly exceeds the cost of the fertilizers, while on Plot 2 the margin is still larger. Where the quantities of fertilizers have been increased, however, on Plots 8 and 9, there has not been a sufficient gain in the increase of crop to compensate the larger cost of the fertilizers. In the case of the barnyard manure the returns for wheat stand nearly midway between those for oats and corn. In other words, taking Plot 6 (because of the abnormally low increase on Plot 5, in the oats test) a ton of manure has produced corn to the value of $1.44; wheat to the value of $1.04, and oats to the value of $0.50.

Plot 2 receives the same quantities of fertilizers on the wheat crop in the continuous as Plot 11 in the rotative cropping, and the increase has been 11 10 bushels of grain and 1117 pounds of straw in the continuous, as against 11.63 bushels of grain and 1351 pounds of straw in the rotative cropping. In the latter case, however, this gain is supplemen-

ted by a further increase of 1750 pounds of hay without any further addition of fertilizers, thus showing a wide difference in the total profit in favor of the rotation.

It appears, therefore, that on the soil under test at Wooster, corn responds more effectively than either wheat or oats to applications of barnyard manure, and also to chemical fertilizers when weight of increase alone is considered. Whether it will pay better to apply fertilizers to corn or to wheat, apparently therefore depends upon the character of the soil and the relative market values of the two crops. As a matter of economic method, the practice of applying barnyard manure chiefly to the corn crop and artificial fertilizers chiefly to the wheat crop, letting the oat crop come between unfertilized, as a gleaner, seems to be supported by these tests.

## SUMMARY OF RESULTS.

These experiments seem to show quite clearly that we cannot safely base a prediction as to the relative behavior of two soils toward applications of phosphoric acid and potash on chemical analysis, however the case may be with regard to nitrogen.

They show that physical constitution may be a more potent factor in determining productiveness than chemical composition.

They show distinctly that for the soils under test, phosphoric acid is the constituent of fertility first needed, and that it is a waste of effort and material to use carriers of nitrogen (such as nitrate of soda) or of potash (ashes, for instance) unless some carrier of phosphoric acid is also used.

Nitrogen appears to be the element most needed, after phosphoric acid, on both these soils, and its effect seems to be greater on the soil shown by analysis to be most deficient in this substance. It appears, however, that when crops are grown in rotation with clover, even though the clover crops are comparatively small, the quantity of nitrogen which can be used with economy is far below the theoretical needs of the crop, as deduced from chemical composition,

On the other hand, these experiments very decidedly indicate that, for the soils and the crops under consideration, it is not wise to omit nitrogen altogether from the fertilizer. Just what proportion this constituent should bear to the phosphoric acid cannot be definitely determined, but it seems that for the soil at Strongsville, which had accumulated a considerable reserve of nitrogen during a long rest in pasture, 3 per cent. of nitrogen (equal to nearly 4 per cent. of "ammonia") has not been too large a proportion, while it would seem that a still larger quantity might be used to advantage on the badly worn soil used in the Wooster test.

While the need of potash is relatively less urgent than that for phosphoric acid or nitrogen, yet it produces an additional increase of

crops after both these have been employed. Although the quantity of potash found in the two soils by chemical analysis is practically identical, yet the effect of potash is much more marked on the soil at Wooster than on that at Strongsville. In this case, as in that of nitrogen, we cannot attempt to prescribe a definite proportion of potash for all soils: but in both cases it would seem that the quantity might be increased for soils which have been subjected to exhaustive cropping.

PREVIOUS PUBLICATIONS OF THE OHIO AGRICULTURAL EXPERIMENT STATION.

Bulletin 120—The annual report for 1899–1900, contains a list of all publications of this Station previous to that date Subsequent publications are as follows.

Bulletin 121—A condensed handbook of the diseases of cultivated plants in Ohio.

Bulletin 122—Onion smut—Preliminary experiments.

Bulletin 123—Grape rots—Experiments in prevention.

This page intentionally blank.